



Apparent sex reversal of male Fall-Run Chinook salmon in California

Environmental Issue

- Evidence suggesting altered sexual differentiation in Pacific salmon has alarmed fisheries biologist.
 - Incongruence between genetic and phenotypic sex in Chinook salmon due to altered sexual differentiation may negatively impact population genetic diversity and indicate exposure to endocrine disrupting chemicals (EDCs).
- Apparent sex-reversed, male Chinook (XY-females) have been documented in California (Table 1 and map).
 - The Fall-Run of Chinook salmon is an important commercial & recreational fishery resource.
- There are few biomarkers of EDC exposure and little data exists concerning population-level effects of EDC exposure in wildlife which may reflect potential human exposure.

Chinook are susceptible to environmental contaminants due to their life history characteristics. Exposure of developing embryos to EDCs can alter their genetically programmed sexual differentiation.

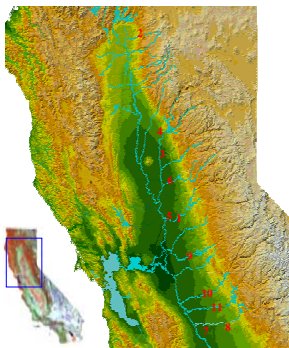
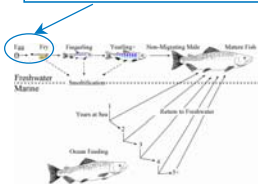


Table 1. Phenotypic female fall-run Chinook positive for a male genetic probe in 2002. The total number of females screened for each site is in parentheses. All 281 phenotypic males had a male genotype. Super-scripts indicate sampling location on map. (From Williamson and May 2002)

Sampling Location	Fish w/ ovaries that have male genetic marker	% XY-Females
Sacramento (SAC) R. Basin:		
American River ¹	1 (29)	3
Battle Creek ²	11 (46)	24
Feather River ³	1 (43)	2
Feather River Hatchery ⁴	2 (30)	7
Nimbus Hatchery ⁵	5 (48)	10
Yuba River ⁶	1 (11)	9
Sacramento R. Basin Total:	21 (207)	9
San Joaquin (SJR) R. Basin:		
Merced River ⁷	4 (39)	10
Merced River Hatchery ⁸	13 (50)	26
Mokelumne River Hatchery ⁹	5 (50)	10
Stanislaus River ¹⁰	6 (44)	14
Tuolumne River ¹¹	4 (43)	9
San Joaquin R. Basin Total:	32 (226)	14
SAC and SJR Basins:	53 (433)	12

Screening progeny from artificial crosses using normal and XY-females



Impact

- Chinook salmon Restoration
 - Information gained from this study will assist the U.S. Fish and Wildlife Service in assessing the relative effects of altered sexual differentiation on genetic and reproductive health of fall-run fish.

Acknowledgements

Special thanks goes to Paul Lutes & Eric Hallen of the Center for Aquatic Biodiversity & Aquaculture (UC Davis), Mike Kozart of the Merced River Fish Hatchery, sampling crews of CDFG, USFWS, DWR, and my co-author Bernie May. Funding for this research was also provided by a CALFED grant (#113322J006) through the USFWS Anadromous Fish Restoration Program.

Citation: Williamson, Kevin S., Bernie May (2002). Incidence of phenotypic female Chinook salmon (*Oncorhynchus tshawytscha*) positive for the male Y-chromosome specific marker OY1 in the Central Valley, California, U.S.A. Journal of Aquatic Animal Health 14(3): 176-183.

Scientific Approach

- Hypotheses:** (1) Do phenotypic female Fall-Run Chinook bearing a XY genotype produce viable eggs?
- (2) Does a controlled cross between a normal male (XY) and a sex-reversed male (XY) produce a 3:1, male to female, sex-ratio in the offspring?

Research Action: Controlled breeding experiments using Chinook with incongruent genotypic and phenotypic sex were performed to evaluate the pattern of inheritance of sex-specific probes. Genetic and morphological analysis of offspring sex-ratios was used to test the genetic probes as biomarkers of altered sexual differentiation of Chinook.